(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 028 558 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.08.2000 Bulletin 2000/33

(51) Int Cl.7: **H04L 5/02**

(21) Application number: **99850018.5**

(22) Date of filing: **09.02.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicants:
- **TELIA AB**
123 86 Farsta (SE)
- **STMicroelectronics S.A.**
38926 Crolles cedex (FR)

(72) Inventors:
- **Isaksson, Mikael**
973 42 Lulea (SE)
- **Johansson, Magnus**
972 41 Lulea (SE)
- **Mestdagh, Denis Julien Gilles**
38410 Saint-Martin d'Uriage (FR)
- **Mazzoni, Simone**
38000 Genoble (FR)

(74) Representative: **Akerman, Marten Lennart**
Albihns Patentbyra Malmö AB
P.O.Box 4289
203 14 Malmö (SE)

(54) **A method and apparatus for reducing cyclo-stationary cross-talk noise**

(57) The invention relates to a method and arrangement for reducing cyclo-stationary cross-talk noise and more particularly to mitigate the effects of cyclo-stationary cross-talk noise from narrow band time divided duplex (TDD) systems into a wide band transmission system within a copper wire-pair transmission network. The TDD system operates in a lower part of the spectrum. In accordance with the invention, the wide band transmission system operates with frequency divided duplex (FDD). The wide band is divided in at least two bands, such that the lower band is at least partly overlapping the time divided duplex system. The lower and the higher band are transmitting in opposite directions. The transmission direction of the frequency bands is switched so that the lower band of the wide band transmission system always transmits in the same direction as the time divided duplex system. With this arrangement the near end cross-talk from the TDD system into the wide band transmission system is avoided and the far end cross-talk from the TDD system will be the limiting noise source.

EP 1 028 558 A1

Description

Field of the invention

[0001] The present invention relates to a method and arrangement for reducing cyclo-stationary cross-talk noise and more particularly to mitigate the effects of cyclo-stationary cross-talk noise from narrow band time divided duplex systems into a wide band transmission system within a copper wire-pair transmission network. The wide band transmission system utilises frequency division duplex and the frequency band is divided into pairs of frequency bands having opposite transmission directions. The transmission directions of the frequency bands are switched in synchronism with the cyclo-stationary cross-talk noise from the time divided duplex systems.

State of the art

[0002] In certain copper access networks there exist narrow band TDD systems (a.k.a ping-pong systems) at low frequencies that introduces a rather complex cross-talk noise in neighbouring copper pairs in the same cable. One highly relevant example is an ISDN variant called TCM-ISDN (TCM - Time Compressed Mode) that is used primarily in Japan. Such TDD system operates in such a way that the signalling up-stream (from the premises to the central office) and downstream (from the central office to the premises) is divided in different time slots, i.e. all the systems in the same cable is time synchronised.

[0003] The cross-talk noise from the TDD system introduced in neighbouring copper pairs will be time variant according to the direction of transmission of the TDD system, i.e. the TDD causes cyclo-stationary cross-talk noise in neighbouring pairs. In certain time periods there will be NEXT (Near End Cross-Talk) and in the other time periods there will be FEXT (Far End Cross-Talk). From a channel capacity point of view, the NEXT is far more damaging than the FEXT since the power spectral density of NEXT is stronger than the power spectral density of FEXT.

[0004] Systems that uses higher band width might however be installed in the same cable and overlap the spectrum of the TDD cross-talk noise, e.g. VDSL (Very high bit-rate Digital Subscriber Lines) systems or ADSL (Asymmetric Digital Subscriber Lines). In this case, the lower part of the spectrum will be affected by this cyclo-stationary cross-talk noise. A VDSL system uses frequencies up to about 10 MHz, while the TDM-ISDN perhaps affects the frequencies up to about 2 MHz.

[0005] The optimum performance will be achieved when the new installed system is synchronised with the TDD system in such a way that only FEXT is introduced between the two systems. This is the same as arranging the signalling on the new systems in such a way that the direction of transmission is the same as in the TDD system.

[0006] One possibility to optimise VDSL according to the TCM-ISDN is to design VDSL as a TDD system with the same time synchronisation as TCM-ISDN, i.e. only transmit VDSL downstream when TCM-ISDN transmits down stream and vice versa. One problem doing so is that the period time for TDM-ISDN is 400 Hz which causes a system delay, or system latency, that is too high than specified for VDSL and can in most cases not be accepted.

[0007] The present invention solves the above problem by dividing the frequency range of the wide band transmission system into at least two bands transmitting in opposite directions. The lower band, which is affected by the cross-talk from the TDD system, is synchronised with the TDD system such that they always transmit in the same direction. With this arrangement the near end cross-talk from the TDD system into the wide band transmission system is avoided and the far end cross-talk from the TDD system will be the limiting noise source. The simultaneous switching of transmission directions in the two frequency bands does not add extra latency to the wide band transmission signal.

Summary of the invention

[0008] Thus, the present invention provides a method for reducing cyclo-stationary cross-talk noise from a narrow band time divided duplex system into a wide band transmission system in a copper wire-pair network, wherein the TDD system operates in a lower part of the spectrum.

[0009] In accordance with the invention, the wide band transmission system operates with frequency divided duplex. The wide band is divided in at least two bands, such that the lower band is at least partly overlapping the time divided duplex system. The lower and the higher band are transmitting in opposite directions. The transmission direction of the frequency bands is switched so that the lower band of the wide band transmission system always transmits in the same direction as the time divided duplex system.

[0010] The invention also relates to an arrangement for performing a method. The invention is defined in the independent claims 1 and 7, while preferred embodiments are set forth in the dependent claims.

Brief description of the drawings

[0011] The invention will be described below in detail with reference to the attached drawing, of which the only figure is a signal frequency diagram relating to an arrangement in accordance with the invention.

Detailed description of preferred embodiments

[0012] For ease of reference we herewith give a list of the abbreviations used throughout the specification:

TDD	Time Division Duplex
FDD	Frequency Division Duplex
TCM	Time Compressed Mode
NEXT	Near End Cross-Talk
FEXT	Far End Cross-Talk
VDSL	Very high bit-rate Digital Subscriber Line
ADSL	Asymmetric Digital Subscriber Line

[0013] The present invention describes how the effects of cyclo-stationary cross-talk noise from a narrow band TDD system can be mitigated by letting the wide band transmission system use an FDD system where the direction of transmission in two frequency bands can switch transmission direction simultaneously synchronised to the noise. The invention assumes that the cyclo-stationary cross-talk noise is concentrated to lower frequencies, and further that the FDD system uses a larger signal bandwidth that overlaps the narrower TDD signal bandwidth that is located at lower frequencies.

[0014] This invention describes a way to avoid NEXT from a narrow band TDD system into an FDD system by simultaneously switching transmission direction in two frequency bands synchronously to the TDD systems.

[0015] With reference to Figure 1, let us assume that we divide the FDD spectrum in two frequency bands, A and B, where A is the lower frequency band and B the higher frequency band. Figure 1 shows a wide band FDD system with two signalling bands A and B and cross-talk noise, NEXT and FEXT, from a narrow band TDD system. The TDD system has less signal bandwidth than the FDD system and operates in the lower part of the spectrum. The FDD system spectrally overlaps the TDD cross-talk noise. Since the TDD systems cause cross-talk, NEXT and FEXT, in the lower part of the frequency spectrum, band A in the FDD system suffers more from this than frequency band B that is located in the upper part of the spectrum.

[0016] The FDD direction of transmission should optimally be arranged in such a way that the FDD system transmit downstream in band A and upstream in band B when the TDD system transmit downstream. In the same way the FDD system should transmit upstream in A and downstream in B when the TDD systems transmits upstream. The FDD wide band transmission system is associated with a switching means adapted to switch the transmission direction in the frequency bands. The switch of transmission direction for both bands can be trigged by a synchronisation provided by the TDD system equipment. The FDD system can switch transmission direction in the two frequency bands synchronously to the cyclo-stationary cross-talk noise from a TDD system operating in the same cable (network). The switching of transmission direction in the frequency bands should be arranged so that the lower band of the FDD system always transmits in the same direction as the TDD system and the higher frequency band hence transmit in the opposite direction to the TDD system.

[0017] The invention is not limited to an FDD system with only two bands. There might exist more frequency bands at upper part of the spectrum that actually do not need to be switched. The invention requires, however, that the switching of direction is done in pairs and that the transmission direction of one band is always the opposite of the other. Each frequency band of the FDD system can be used for either upstream of for downstream transmission.

[0018] One benefit with this invention is that it does not cause long latency in the FDD system if the TDD system switches direction with a low periodicity. The simultaneous switching of transmission directions in the two frequency bands does not add extra latency to the wide band transmission signal. With this arrangement the near end cross-talk from the TDD system into the wide band transmission system is avoided and the far end cross-talk from the TDD system will be the limiting noise source.

Claims

1. A method for reducing cyclo-stationary cross-talk noise from a narrow band time divided duplex (TDD) system into a wide band transmission system in a copper wire-pair network, wherein the TDD system operates in a lower part of the spectrum, **characterised** in that the wide band transmission system operates with frequency divided duplex (FDD), the wide band being divided in at least two bands (A, B), such that the lower band (A) is at least partly overlapping the TDD system and the lower (A) and the higher band (B) are transmitting in opposite directions, and in that the transmission direction in the frequency bands is switched so that the lower band of the wide band transmission system always transmits in the same direction as the TDD system.

2. A method in accordance with claim 1, **characterised** in that the frequency bands of the wide band transmission system is switched by means of a synchronisation signal derived from the TDD system.

3. A method in accordance with claim 2, **characterised** in that the synchronisation signal is substantially synchronous with the cyclo-stationary cross-talk noise from the TDD system.

4. A method in accordance with claim 1, 2 or 3, **characterised** in that the wide band is divided into an even number of bands, arranged in pairs, such that the lower and the higher band in each pair are transmitting in opposite directions.

5. A method in accordance with any one of the previous claims, **characterised** in that the wide band transmission system is a very high bit-rate digital subscriber line (VDSL) system or an asymmetric digital subscriber line (ADSL) system.

6. A method in accordance with any one of the previous claims, **characterised** in that the narrow band transmission system is a time compressed mode integrated services digital network (TCM - ISDN) system.

7. An arrangement for reducing cyclo-stationary cross-talk noise from a narrow band time divided duplex (TDD) system into a wide band transmission system in a copper wire-pair network, wherein the TDD system operates in a lower part of the spectrum, **characterised** in that the wide band transmission system is adapted to operate with frequency divided duplex (FDD), the wide band being divided in at least two bands (A, B), such that the lower band (A) is at least partly overlapping the TDD system, and the lower (A) and the higher band (B) are transmitting in opposite directions, and in that the wide band transmission system is associated with a switching means adapted to switch the transmission direction in the frequency bands, so that the lower band of the wide band transmission system always transmits in the same direction as the TDD system.

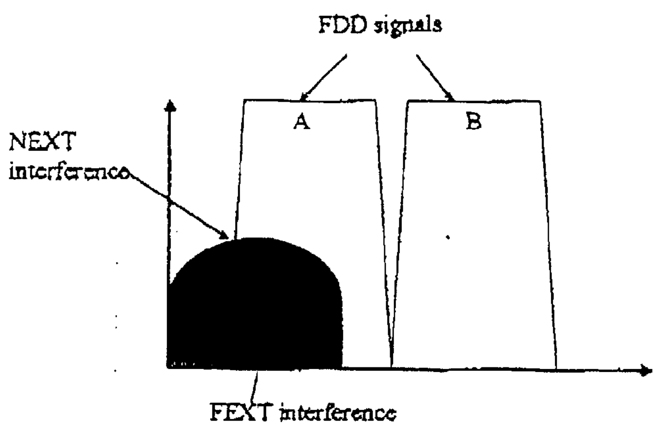
8. An arrangement in accordance with claim 7, **characterised** in that the switching means is trigged by a synchronisation signal derived from the TDD system to switch the frequency bands of the wide band transmission system.

9. An arrangement in accordance with claim 8, **characterised** in that the synchronisation signal is substantially synchronous with the cyclo-stationary cross-talk noise from the TDD system.

10. An arrangement in accordance with claim 7, 8 or 9, **characterised** in that the wide band is divided into an even number of bands, arranged in pairs, such that the lower and the higher band in each pair are transmitting in opposite directions.

11. An arrangement in accordance with any one of claims 7 to 10, **characterised** in that the wide band transmission system is a very high bit-rate digital subscriber line (VDSL) system or an asymmetric digital subscriber line (ADSL) system.

12. An arrangement in accordance with any one of claims 7 to 11, **characterised** in that the narrow band transmission system is a time compressed mode integrated services digital network (TCM - ISDN) system.


FDD signals
A
B
NEXT
interference
FEXT interference

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 85 0018

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION
A	WO 97 06619 A (TELIA AB ;ISAKSSON MIKAEL (SE)) 20 February 1997 (1997-02-20) * abstract * * page 6, line 9 - line 11 * * page 6, line 31 - line 34 * * page 7, line 13 - line 21 * * page 7, line 28 - line 36 *	1,7	H04L05/02
A	US 5 680 394 A (TONG PO ET AL) 21 October 1997 (1997-10-21) * abstract * * column 2, line 50 - line 58 * * column 3, line 15 - line 21 * * column 5, line 35 - line 44 * * column 7, line 16 - line 24 * * column 8, line 10 - line 18 *	1,7	
			TECHNICAL FIELDS SEARCHED
			H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 July 1999	Papantoniou, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 99 85 0018

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-07-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9706619 A	20-02-1997	EP 0883944 A	16-12-1998
		SE 9502775 A	05-02-1997
US 5680394 A	21-10-1997	AU 6478296 A	10-02-1997
		CN 1190511 A	12-08-1998
		EP 0838109 A	29-04-1998
		WO 9703506 A	30-01-1997
		US 5838667 A	17-11-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82